PHOTOPHORESIS ON CHONDRULES - NEW EXPERIMENTAL RESULTS

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Introduction: Photophoresis, as a fourth light-induced force alongside radiation pressure, Poynting-Robertson drag and the Yarkovski effect, exceeds these by orders of magnitude at conditions found in a protoplanetary disk [1][2].

In contrast to the aforementioned forces, photophoresis is not based on a direct acceleration by photons: Gas molecules of the surrounding atmosphere stick to the surface of a unidirectionally illuminated particle. They take on the different temperatures along the illumination axis and therefore leave the surface at the corresponding thermal velocities. This results in a net momentum transfer that is directed away from the light source (e.g. the central star of the protoplanetary disk).

With its inherent pressure- and particle-size-dependence, it not only qualifies as an additional mechanism for particle transport, but also provides an effective way of sorting. These properties make photophoresis an important aspect in explaining the occurence of size-sorted chondrules. In a first campaign of microgravity experiments, the efficiency of photophoresis acting on chondrules could clearly be shown. A follow-up project was initialized to shed light on more detailed aspects of photophoretic acceleration, including rotational properties.

Experiment: To quantify the effect, particularly with regard to chondrules, experiments were carried out at the ZARM drop tower in Bremen, providing approximately nine seconds of microgravity with a residual acceleration of less than 10^{-6} g.

Chondrules originating from the L/LL4-class chondrite Bjurböle are exposed to an intense laser beam in the microgravity environment of the drop capsule at varying ambient pressures. Their motion ist observed with two synchronized cameras aligned perpendicular to each other and the incident direction of the laser beam. In the recorded videostreams the three-dimensional motion of the chondrules can be obtained and rotational frequencies can be determined.

Results: The results for the linear motion are consistent with the outcome of the initial study [3] and the measured accelerations of approximately 10^{-4} m/s^2 are in accordance with the estimates of model forces [4]. Moreover for certain rotating chondrules transverse components in the acceleration could be detected, which hints at a process similar to the Yarkovski effect but with photophoretic momentum transfer. These results are the first experimental data on the interplay between particle rotation, photophoresis and material transport.

References: [1] Wurm G. and Krauss O. 2006. *Icarus* 180:487–495. [2] Wurm G. and Haack H. 2009. *Meteoritics & Planetary Science* 44:689–699. [3] Wurm G. et al. 2010. *Icarus* 208:482–491. [4] Rohatschek H. 1995. *Journal of Aerosol Science* 26:717–734.